

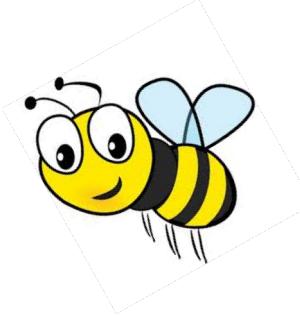


# ML2 Honey Bee Images

Group 4

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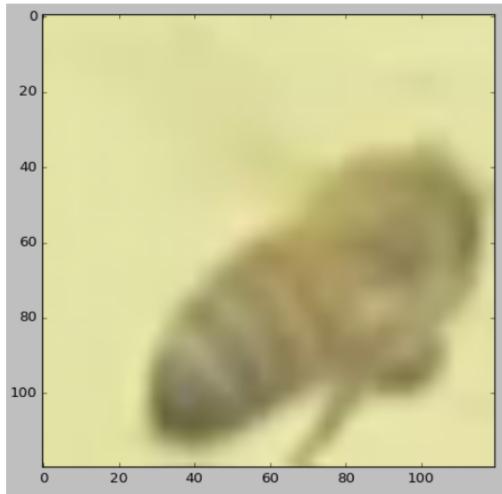
# Introduction



- Dataset: The Bee Image Dataset
- columns:
  - file: 5172 images
  - date: 7/2/18 ~ 9/8/18
  - time: 8:20 ~ 21:13
  - location: 8 locations
  - zip code
  - subspecies: 8 subspecies
  - health: Hive health (healthy, few varroa hive beetles, ...)
  - pollen\_carrying: true / false
  - caste: worker

# Some Examples

- The pictures are extracted from still time-lapse videos
- Then each bee is cropped out to ensure each image has only one bee



Western honey bee  
healthy

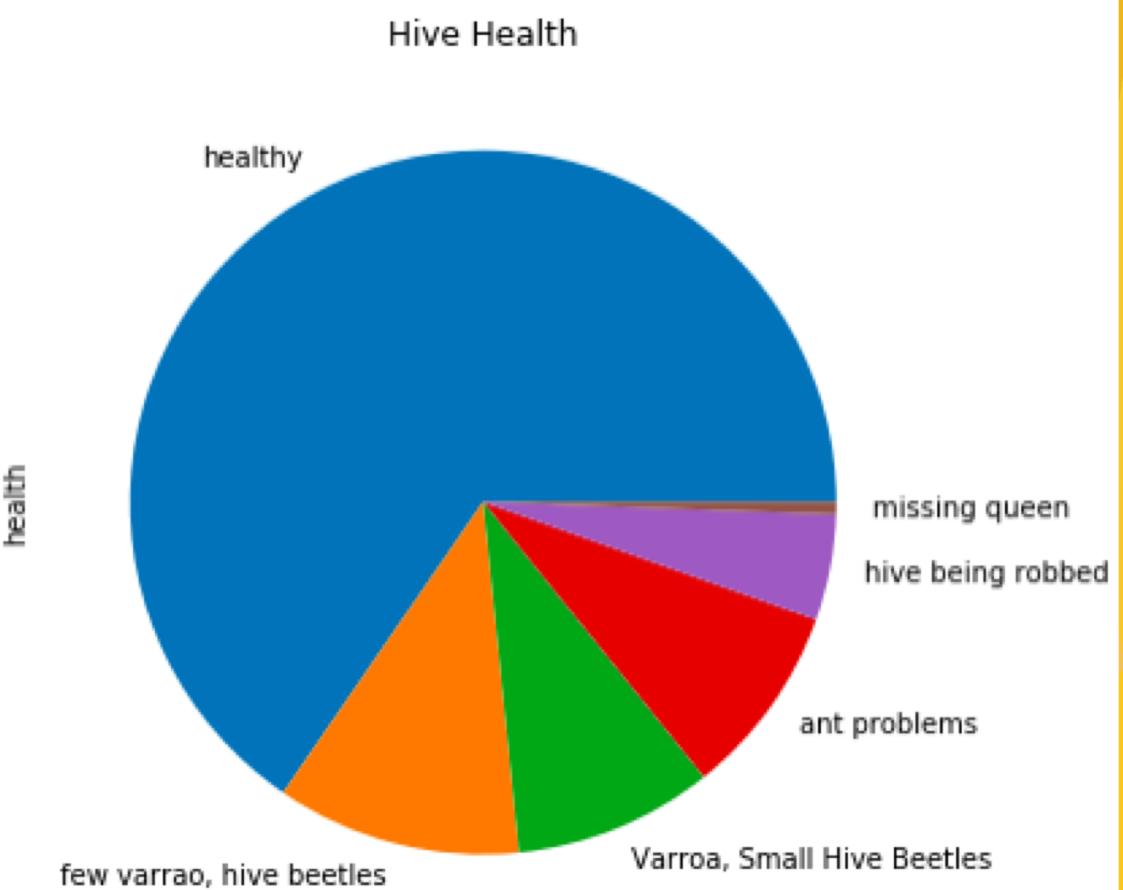
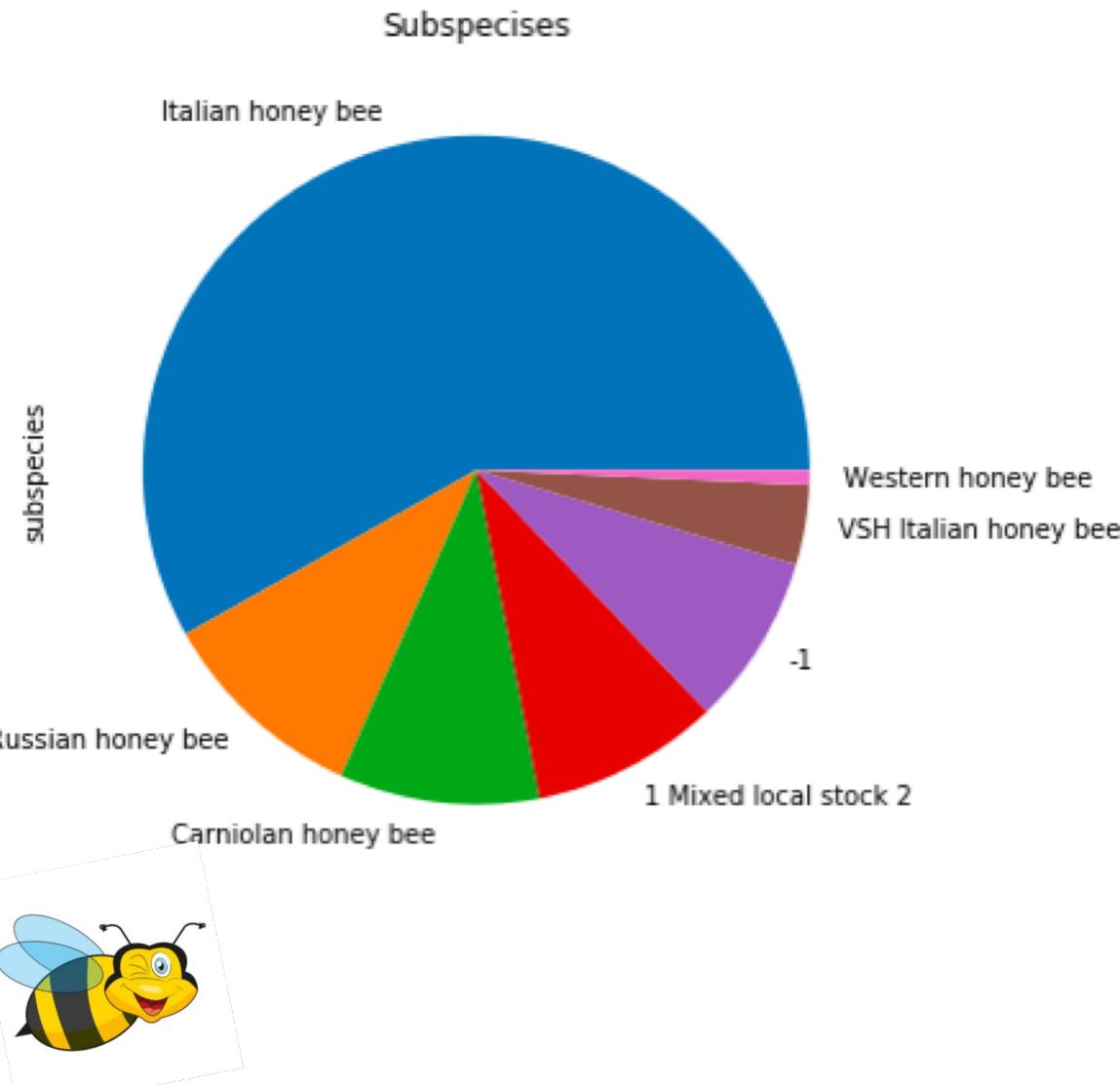


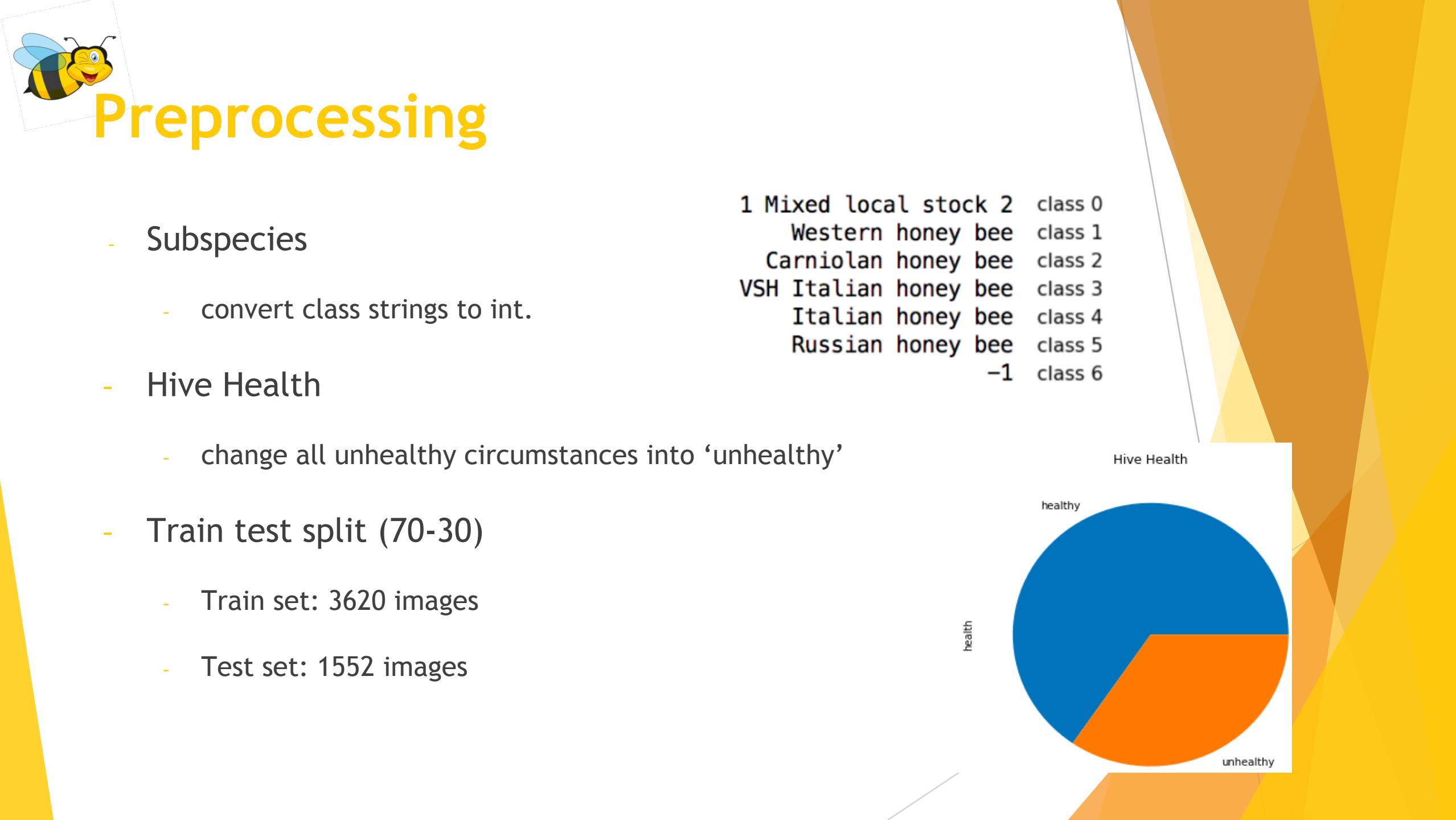
Italian honey bee  
few varroa, hive beetles



Italian honey bee  
healthy

# EDA



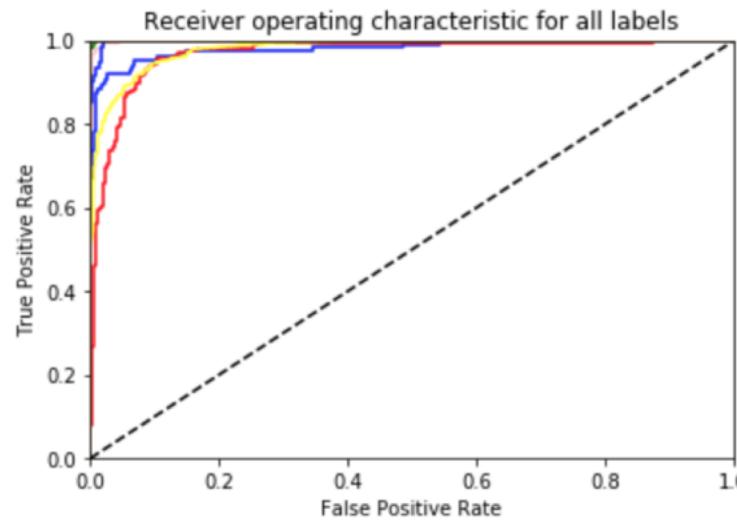


# Subspecies Classification - Keras

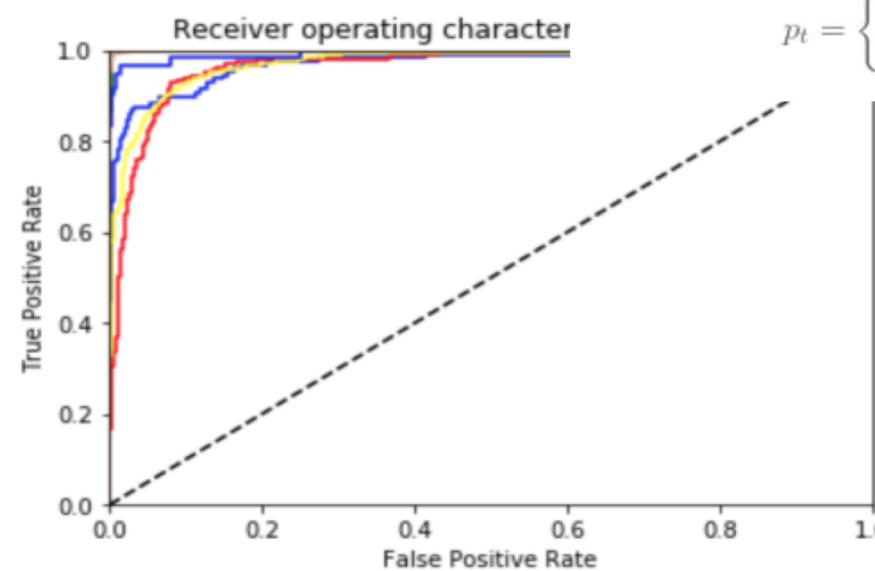


model43_w	4 conv total 15	0.89	0.89	0.82	3,3,3, 3,2,2	Glorot uniform	Adam	weighted_categorical_CE	softmax	83	22	32
model43_f	4 conv total 15	0.93	0.93	0.89	3,3,3, 3,2,2	Glorot uniform	Adam	Focal loss	sigmoid	180	50	32
model431_r005	4 conv total 15	0.86	0.86	0.77	3,3,3, 3,2,2,	Glorot uniform	Adam	Categorical_CE	softmax	185 modelS	2 conv total 8	0.89
model431_r007	4 conv total 15	0.92	0.93	0.88	3,3,3, 3,2,2,	Glorot uniform	Adam	Categorical_CE	softmax	178 modelS	2 conv total 8	0.89
model431_rchaing	4 conv total 15	0.74	0.70	0.54	3,3,3, 3,2,2,	Glorot uniform	SGD	Categorical_CE	softmax	171 modelR	2 conv total 8	0.56
tmodel43_64	4 conv total 15	0.91	0.92	0.86	3,3,3, 3,2,2	Glorot uniform	Adam	Categorical_CE	softmax	164 g	2 conv total 8	0.97
										modelS_sa	2 conv total 8	0.91
										modelS_S	2 conv total 8	0.77
										modelS_sa	2 conv total 8	0.91
										model45	4 conv total 15	0.91
										model43	4 conv total	0.92

## Model 43



```
show_roc_auc(model43_f)
```



The focal loss

$$FL(p_t)$$

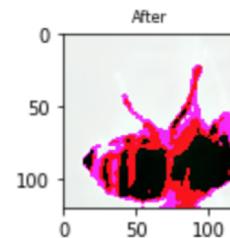
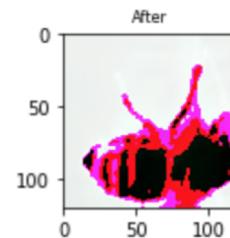
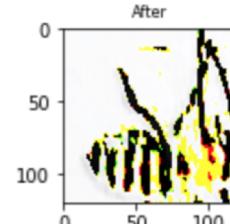
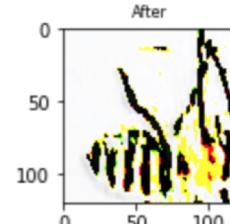
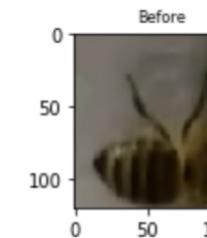
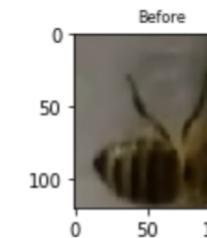
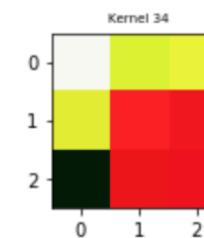
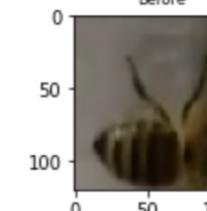
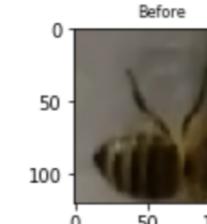
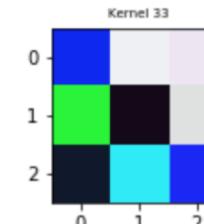
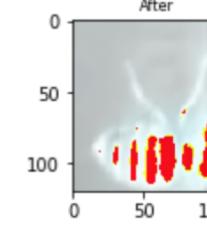
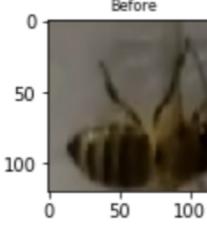
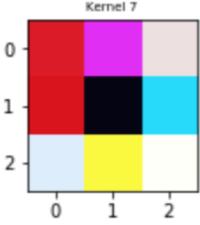
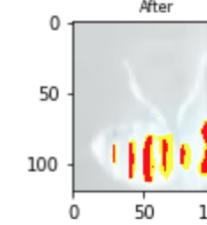
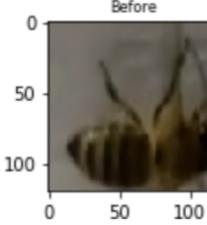
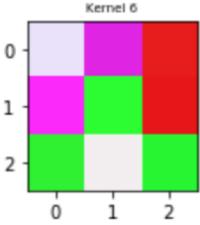
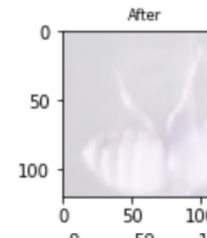
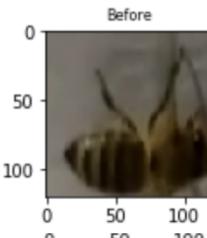
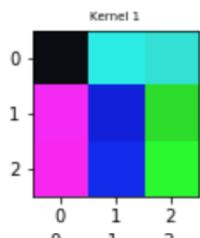
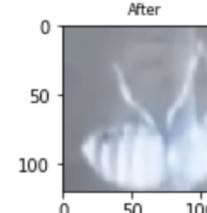
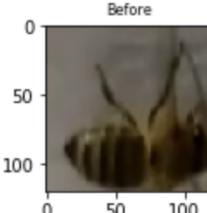
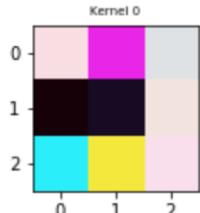
is defined as:

$$FL(p_t) = -\alpha \cdot (1 - p_t)^\gamma \log(p_t)$$

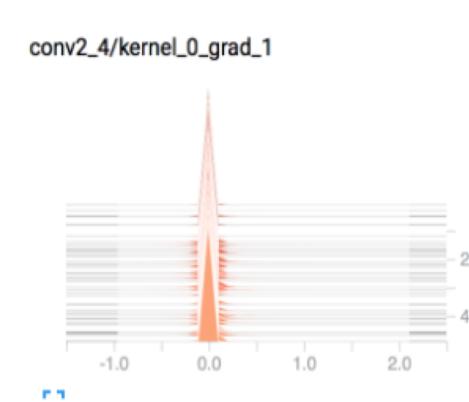
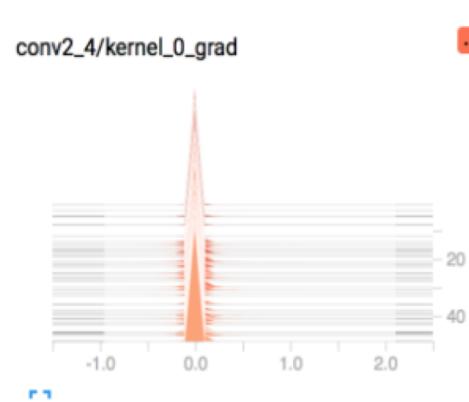
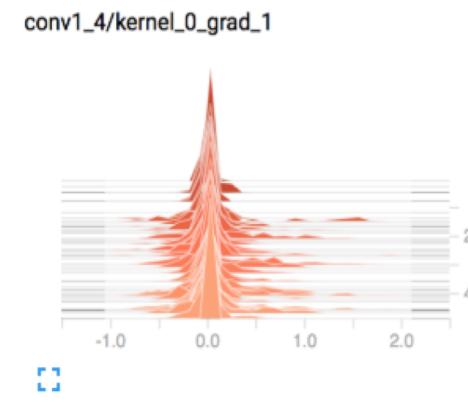
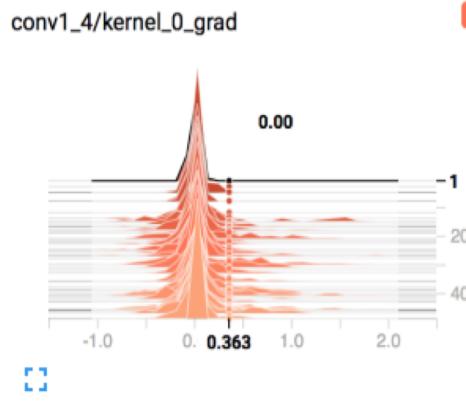
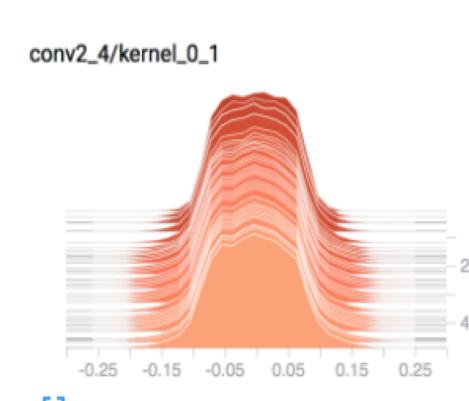
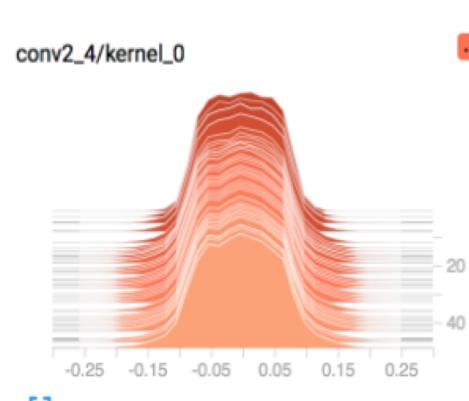
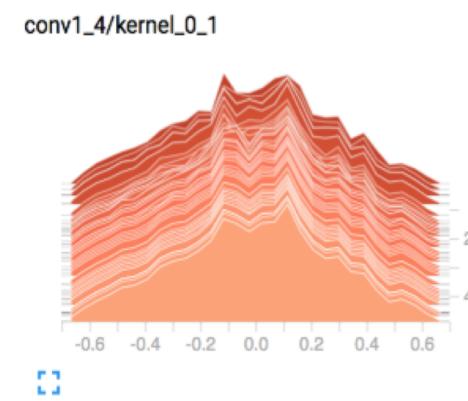
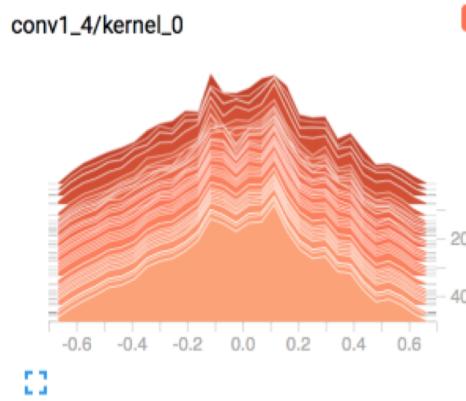
where

$$p_t = \begin{cases} p & \text{if } y = 1 \\ 1 - p & \text{otherwise,} \end{cases}$$

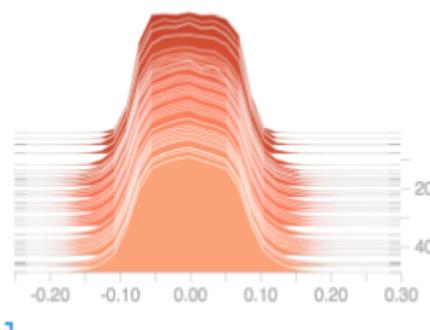
# Kernel visualization



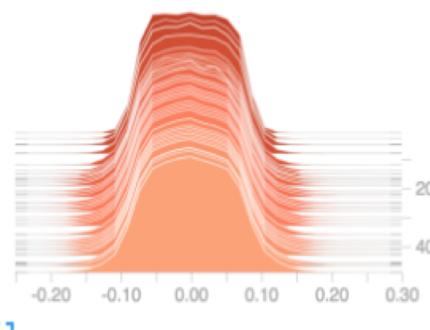
# Tensorboard -- Weight



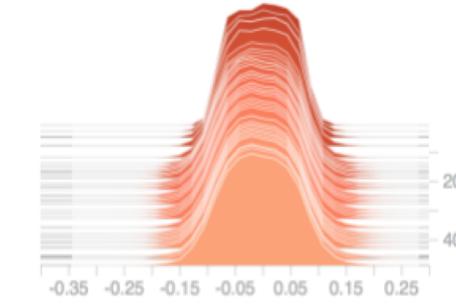
conv3/kernel\_0



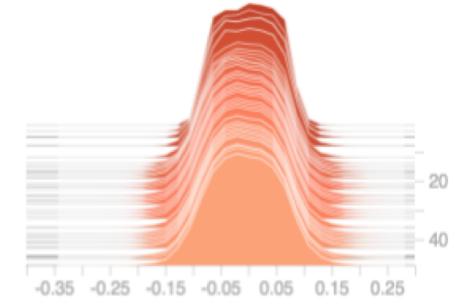
conv3/kernel\_0\_1



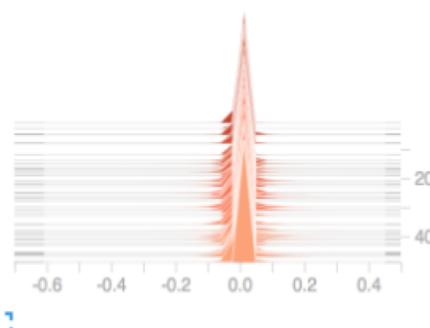
conv4/kernel\_0



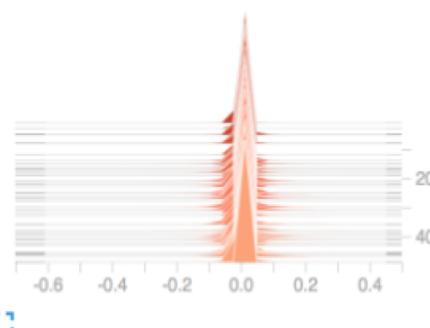
conv4/kernel\_0\_1



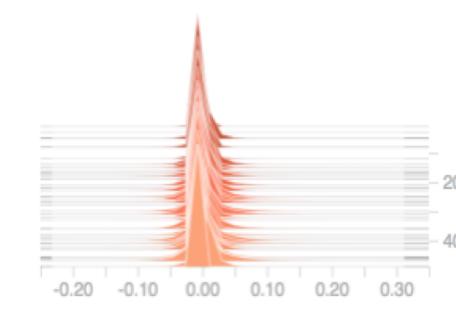
conv3/kernel\_0\_grad



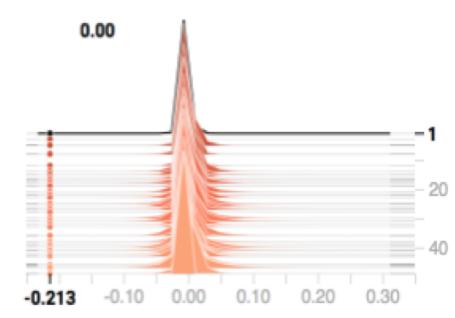
conv3/kernel\_0\_grad\_1



conv4/kernel\_0\_grad



conv4/kernel\_0\_grad\_1



# Hive Health Classification - Keras

- Without Batch Normalization (Epochs = 30)|

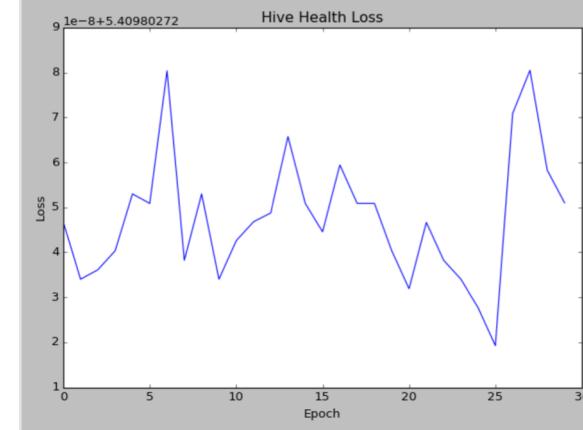
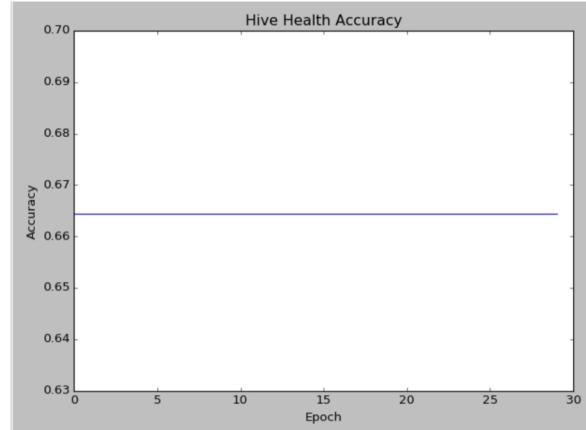
	Training 1(Test Accuracy)	Training 2(Test Accuracy)
<b>Batch Size = 32</b>	<b>0.995</b>	<b>0.992</b>
<b>Batch Size = 64</b>	<b>0.989</b>	<b>0.987</b>

- With Batch Normalization (Epochs = 30)|

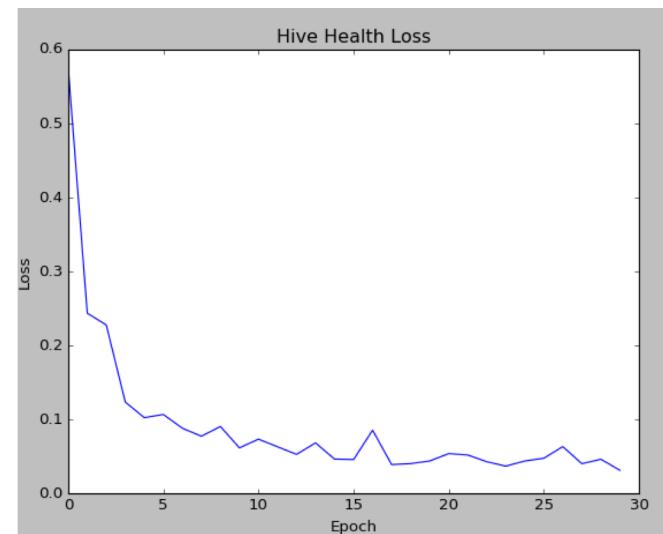
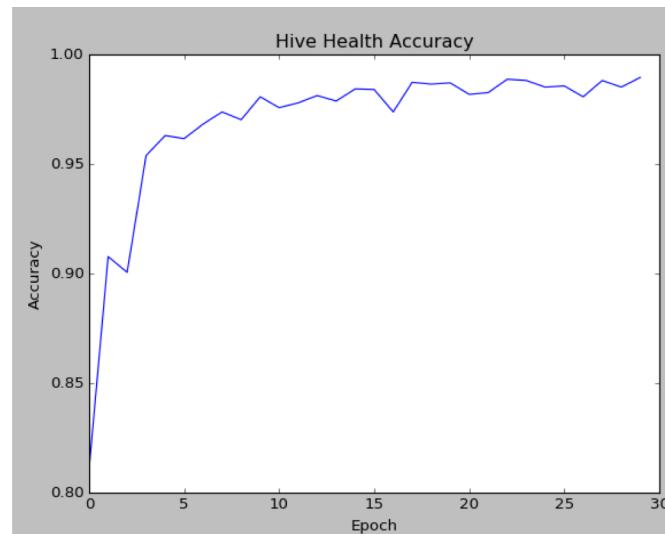
	Training 1(Test Accuracy)	Training 2(Test Accuracy)
<b>Batch Size = 32</b>	<b>0.631</b>	<b>0.631</b>
<b>Batch Size = 64</b>	<b>0.631</b>	<b>0.631</b>



# Hive Health Classification - Keras



	precision	recall	f1-score	support
healthy	0.63	1.00	0.77	979
unhealthy	0.00	0.00	0.00	573
avg / total	0.40	0.63	0.49	1552
	precision	recall	f1-score	support
healthy	0.99	0.99	0.99	979
unhealthy	0.99	0.99	0.99	573
avg / total	0.99	0.99	0.99	1552

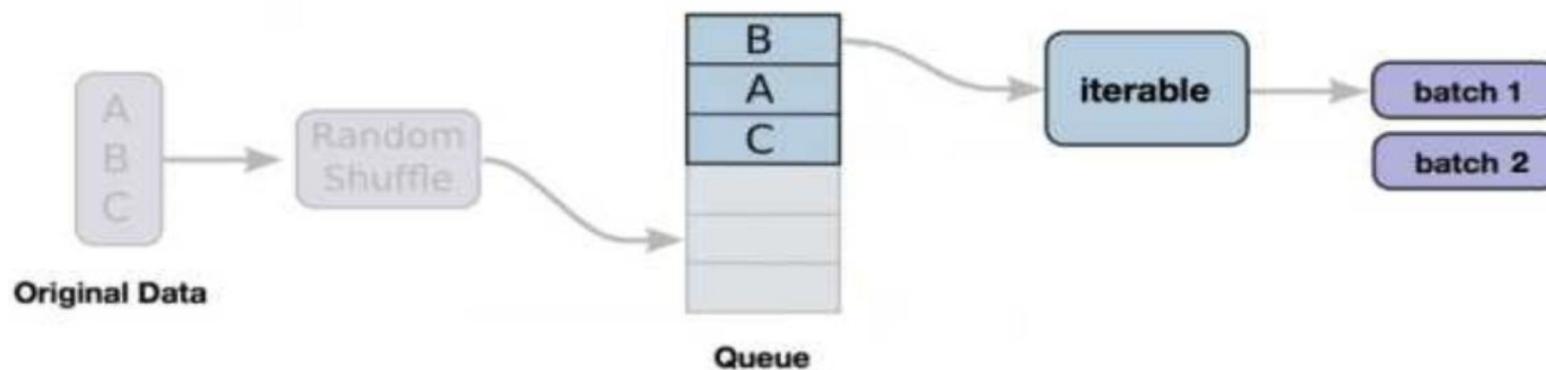


Training 2 Accuracy  
and Loss  
Batch Size = 32,  
Epochs = 30



# Pytorch

## DataLoader



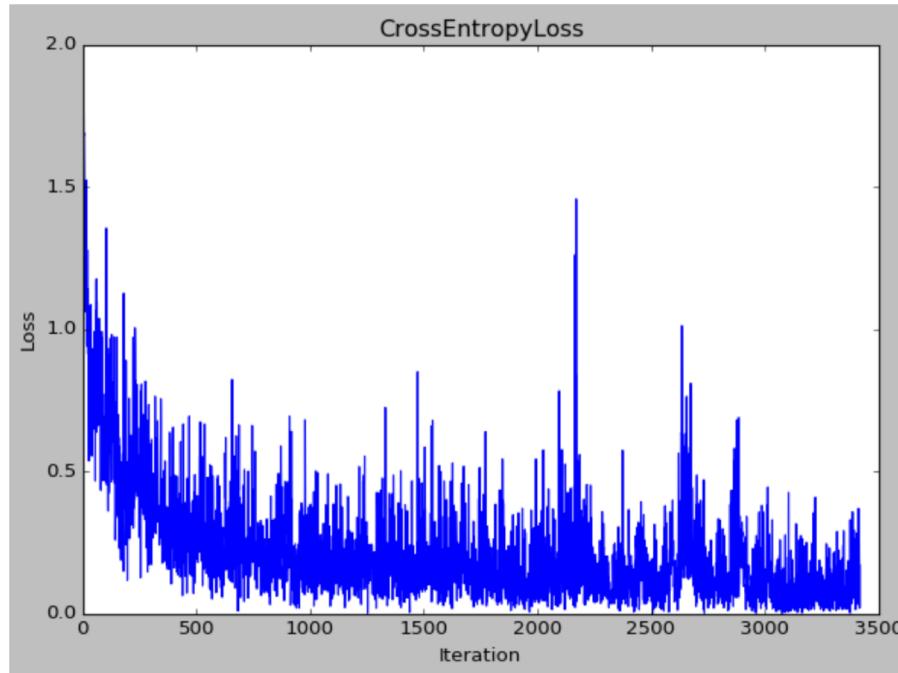
```
output_size = (in_size - kernel_size + 2*(padding) / stride) + 1
```



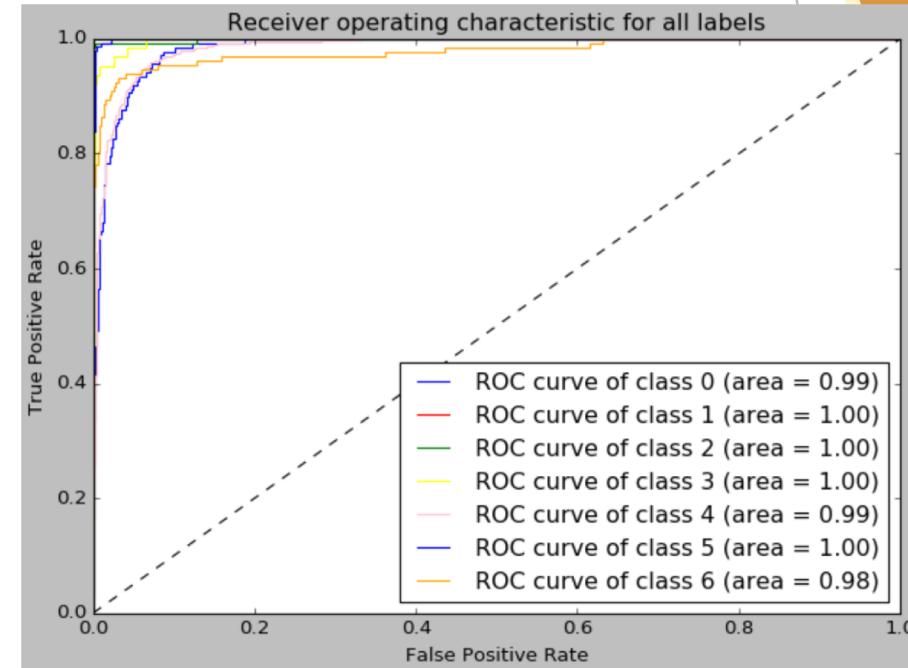
# Subspecies Classification - PyTorch



Training Loss



ROC curve

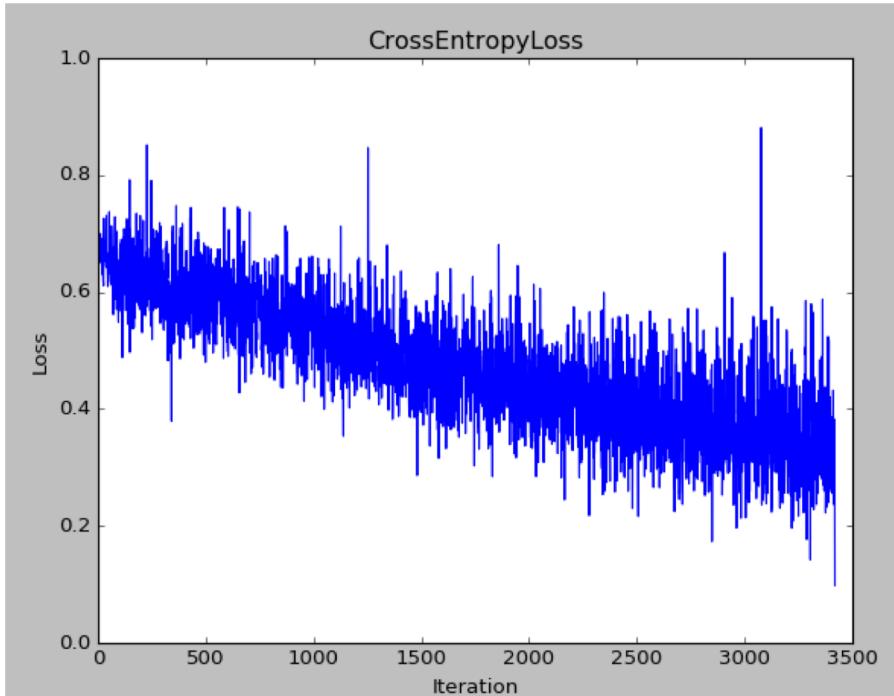


Classification Report

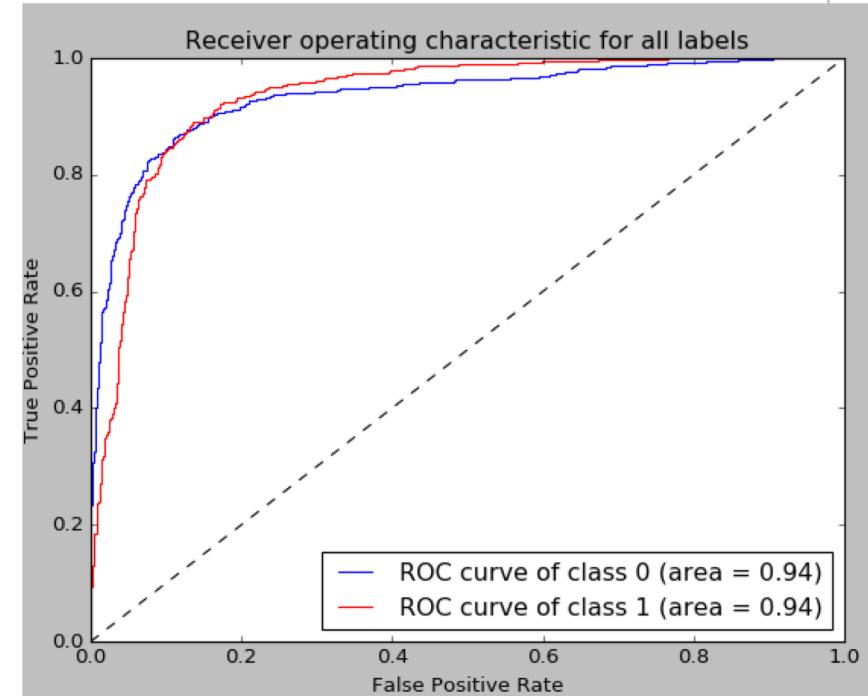
	precision	recall	f1-score	support
1 Mixed local stock	0.63	0.92	0.74	138
2 Western honey bee	0.75	1.00	0.86	6
Carniolan honey bee	0.93	0.99	0.96	142
VSH Italian honey bee	0.86	0.95	0.90	64
Italian honey bee	0.97	0.89	0.93	914
Russian honey bee	0.89	0.99	0.94	155
-1	0.97	0.76	0.85	133
avg / total	0.92	0.91	0.91	1552

# Hive Health Classification - PyTorch

Training Loss



ROC Curve



Classification Report

```
('Computational Time:', 198.369313955307)
Test Accuracy of the model on the 1552 test images: 87 %
precision    recall    f1-score   support
```

	precision	recall	f1-score	support
healthy	0.89	0.94	0.91	1035
unhealthy	0.85	0.76	0.80	517
avg / total	0.88	0.88	0.87	1552



# Conclusion



- Subspecies F1 score: 0.93
- Hive Health F1 score: 0.99
  
- For future research, we could use more layers and change pooling methods.
- Collecting more images in the dataset to fix the imbalanced problem, we would have a better accuracy on some of the bee classes.

# Thank you

